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Application For Patent

אני, (שם המבקש, מענו ולגבי גוף מאוגד - מקום התאגדותו)
I (Name and address of applicant, and in case of body corporate-(place of incorporation

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Owner, by virtue of .... Operation of Law of an invention the title of which is

(בעברית) (Hebrew) שיטה לאיתור חפצים נסתרים

(באנגלית) (English) METHOD OF DETECTING CONCEALED OBJECTS

מבקש בזאת כי ינתן לי עליה פטנט
hereby apply for a patent to be granted to me in respect thereof

• בקשת חלוקה - Application of Division	• בקשת פטנט מוסף - Application for Patent Addition	• דרישת דין קדימה Priority Claim		
מבקשת פטנט from Application	לבקשה/לפטנט to Patent/.Appl	מספר/סימן Number/Mark	תאריך Date	מדינת האיגוד Convention Country
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שיטה לאיתור חפצים נסתרים

METHOD OF DETECTING CONCEALED OBJECTS

METHOD OF DETECTING CONCEALED OBJECTS

FIELD OF THE INVENTION

The present invention relates to remote detection and, more particularly, to a method of detecting concealed objects such as weapons.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention is of a method of detecting a concealed object. Specifically, the present invention can be used to identify a suicide bomber.

The description herein includes by reference the following files that are on the accompanying CD-ROM:

belt1_15.avi

belt2_20.avi

belt_2.ppt

The present invention is described in detail in the accompanying Appendices A and B, as well as in the file "belt_2.ppt" on the accompanying CD-ROM.

While the invention has been described with respect to a limited number of embodiments, it will be appreciated that many variations, modifications and other applications of the invention may be made.

WHAT IS CLAIMED IS

1. A method of detecting a concealed object, comprising the steps of:

(a) transiently changing a temperature of at least part of a surface of a body at which the object is concealed;

(b) acquiring a plurality of thermal images of the object; and

(c) identifying the concealed object in said thermal images.

2. The method of claim 1, wherein said body includes a person and wherein the object is concealed under a garment worn by said person.

3. A method of detecting a concealed object, substantially as described herein.

4. The method of claim 1, for industrial use.

5. The method of claim 1, for medical use.

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June 24, 2003

Appendix A: a Method for Detecting Concealed Hazards carried on Humans by means of Thermal IR Imaging.

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SCD

Introduction

Most of the methods developed today for detecting concealed explosives require close proximity to the object. These are, among others, metal detection, X-ray scanning, gas chromatography and mass spectroscopy. Even bizarre ideas such as neutron spectroscopy have been proposed. A promising exception is Laser spectroscopy that is claimed to be capable of detecting suspicious vapors from a distance of several meters. Common to all of the methods above is the specific detection of hazards. In this proposal we suggest to focus on the human instead. There is one property of humans that we can use for IR detection of hazards and this is the thermal regulation of the human body. While the environment temperature can change by tens of degrees, the human body temperature is regulated to within fractions of a degree. Thus the human body provides a perfect background for thermal detection of concealed hazards.

Heat Capacity Contrast

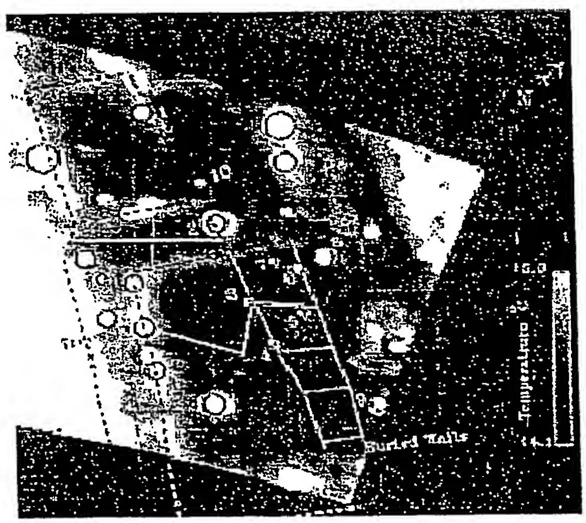

Fig.1 Thermal air-photo of Tel-Levia. The dashed lines are exposed walls. The solid lines are buried walls discovered by the method.

Fig.1 is a thermal air-photo of an archeological site (Tel-Levia) [1]. The dashed lines are exposed walls. Their thermal signature is very apparent. The solid lines indicate buried walls that were discovered by the heat capacity contrast and were not known before. Note that the total temperature scale displayed in the figure is less than 2 degrees Celsius. By the same methods NASA was using thermal maps of large areas to determine the geological composition of these areas [2]. The proposal is to use a similar method to detect concealed hazards on the human body. The distance to the target will be determined by the resolution (price) of the camera. There are two advantages of the proposed method . One was mentioned above, a constant temperature background. (Even

small variations of the body temperature can be calibrated using physiological data). The other is the ability to control the surrounding temperature.

Time Dependence

The thermal air-photo in figure 1 was taken under optimal conditions, close to dawn, when the temperature contrast is the largest. When checking human suspects we have an advantage since we can control the environment temperature. Consider the following scenario: a terrorist is entering an air-conditioned shopping center. The environment temperature changes abruptly while the human body does not. Any foreign object will adjust to the new conditions by a transient thermal distribution leading to the new steady state. Optimal conditions for detection can thus be set by picking the right moment of taking the photo, or by following the time dependent behavior. Automated analysis can be used to produce an alarm without the necessity of a human observer.

Spectroscopy

After gathering enough information, Fourier analysis of the transient behavior can provide information, not only on the existence of foreign objects, but also on the material and dimensions of the constituents.

Systems

SCD can provide two types of systems: A low end system to be put at the entrance to shopping centers and restaurants. A camera could be installed even in a bus for remote sensing of suspicious passengers. If the detection is quick enough (automatic data processing), this method can solve also the bottleneck problem of lines before security checks that are being themselves a target for terrorist attacks. If the time dependence is necessary, security checks can be made in restricted areas inside shopping centers etc. where air condition cooling or heating is operated. Possible solutions for buses and shopping centers are shown below.

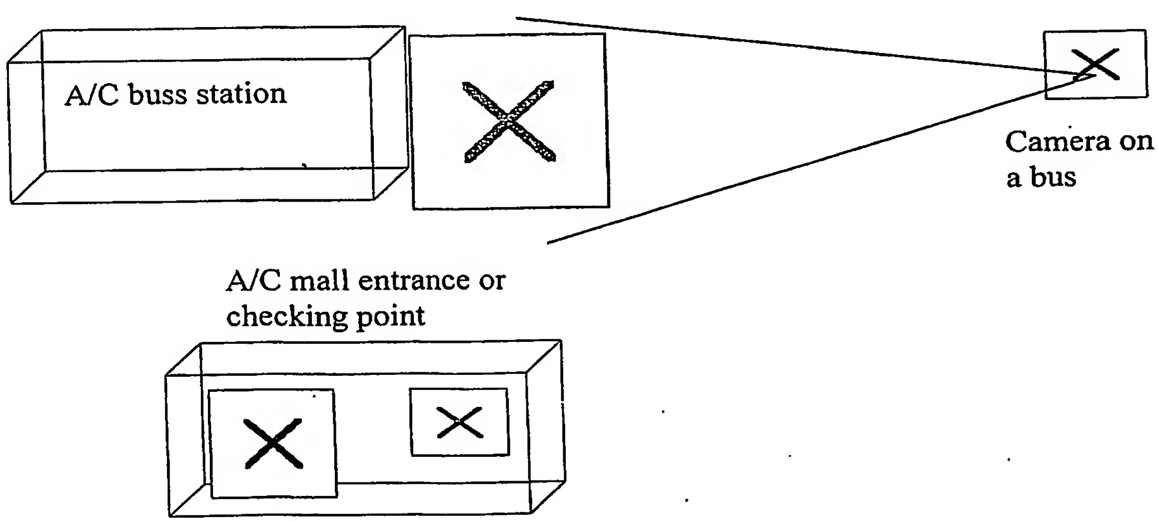

Fig. 2: Possible solutions for busses (up) and shopping centers (down). They can be used also at checking points in city centers and borders.

The other type of system SCD could provide is a high end system to be put on unmanned planes or balloons. High end cameras could thus resolve small thermal differences from a distance, covering large areas such as city centers and border lines.

Counter measures

Thermal contrast may be avoided by using a heavy coat. In the winter, people will be asked to take it off, a natural thing to do entering a heated environment. In the summer, these people could be detected from a large distance, carrying a special thermal signature.

Marking

An additional measure could be a special marking to designate people or cars that have passed a checking point. Thus for example a solution of a transparent conductor such as ITO can be used to paint car roofs for identification by thermal cameras. A different marking can be used to designate potential suspects. An unmarked car then becomes a suspect too. Such paint can be used to paint cloths as well, especially coats. The painting could be done at the shop or at the border checking point.

Action needed

Since most of the means are available at SCD (thermal cameras of variable sensitivity and resolution + image analysis software), it is proposed to start experiments for testing the potential of the method.

References

1. E. Ben-Dor et. al., in *Remote Sensing*, Editors B.Z. Kedar and A. Danin (2000) p. 213
2. R. G. Witt et. al., Int. J. Remote Sensing 6 (1985) p. 1623
3. P. Slater, *Remote Sensing* (Addison Wesley 1980). p.462

July 3, 2003

Appendix B: A method for detecting concealed hazards on humans

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SCD

1. Introduction

Appendix A proposed a new way of detecting concealed hazards on humans, by using thermal inertia contrast and changing abruptly the environment conditions. This Appendix describes the first experimental results that demonstrate the effect and the potential of the method. Chapter 2 describes briefly the theory and chapter 3 describes the camera system and the results, available as a video clip, taken by a thermal camera.

2. Theory

The image contrast is governed by the equation

$$\kappa(\mathbf{r})\frac{\partial v(\mathbf{r},t)}{\partial t} = \nabla^2 v(\mathbf{r},t) \tag{1}$$

where $v(\mathbf{r},t)$ is the temperature field and $\kappa(\mathbf{r})$ is the thermal diffusivity. The boundary conditions are to a good approximation:

$$v(\mathbf{r}_B,t) = T_B \tag{2}$$

$$-K_s\nabla v(\mathbf{r}_S,t) = -\varepsilon(\mathbf{r}_S)\sigma v^4(\mathbf{r}_S,t) + I_B + K_e(v-T_e) \tag{3}$$

where $\mathbf{r}_B$ and $\mathbf{r}_S$ are any points on the body and shirt respectively. T_B and I_B are the body temperature and heat flux. I_e is the heat supplied by the environment and $\varepsilon(\mathbf{r}_S)$ is the position dependent emissivity of the shirt. K_s and K_e are the shirt heat conductivity and the air convection coefficients. Since $v(\mathbf{r}_S,t)$ is very close to the environment temperature T_e, condition (3) can be linearized using the expansion

$$\varepsilon(\mathbf{r}_S)\sigma v^4(\mathbf{r}_S,t) = \varepsilon(\mathbf{r}_S)\sigma T_e^4 + 4\varepsilon(\mathbf{r}_S)\sigma T_e^3(v-T_e) \tag{4}$$

If we now examine equations (1)-(4) we see that in the steady state, where

$$\nabla^2 v(\mathbf{r},t)=0 \tag{5}$$

only geometry, through equation (5), and surface properties, through equation (3) determine the image contrast. Therefore we can observe fine wrinkles of the shirt and small variations in shirt material, but we cannot observe any hidden objects if they are not in direct contact with the shirt. However, if we change the environment temperature T_e, we get back equation (1) and therefore the image contrast is determined for a limited time by the bulk thermal properties as well. In other words, changing the environment temperature makes the shirt transparent to some degree for a short period of time.

3. Experimental results

Thermal pictures were taken by Jade thermal camera produced by CEDIP with nominal NETD of 30 mK @ 25 C and @ Ti=3ms. The heart of the camera is an SCD InSb detector, with sensitivity at 3-5 um. The maximum frame rate is 60 Hz @ Ti=2ms.

Initial experiments showed that it was possible to detect small objects concealed in a shirt pocket. Even a pen could be identified. However, small objects attached to the body were not detected. It was time to go for the real thing.

The film (the file belt1_15.avi in the accompanying CD-ROM) presents a terrorist (myself) putting an "explosion belt" on his body. The belt is composed of "Plastelina" in a weight of 2 kg and two led wires. The whole thing is wrapped in a thin plastic foil. In frame 00:00, my shirt is held so that no indication of any concealed object is apparent. This picture was taken about 30 minutes after putting on the belt, so that the belt already picked up the body temperature. Immediately after putting on the belt, there is a clear shadow, indicating the concealed belt, but this is a detection mode that requires some luck (observing a suspect immediately after he put on the belt). In frame 00:19 a blower (fan) is used to heat the close surrounding of the terrorist. Cooling by air condition should cause a similar effect. However, it was easier to demonstrate the effect with a blower. The heat from the blower causes saturation of the picture and the contrast completely disappears. Now the heating is stopped and we are in the transient state as we wanted. Frame 00:42 was taken shortly (one second) after the blower was stopped. We see the contrast on the shirt being recovered, but there is no sign of the belt yet. Frame 00:46 was taken 5 seconds after the blower was stopped. We see a clear shadow on the shirt indicating the concealed belt. No such contrast appears in the visible range. Frame 01:20 was taken after additional 30 seconds. The belt reached now its steady state and the contrast completely disappeared.

This experiment demonstrates the potential of the method. It should be mentioned that the pictures were taken by an inexperienced operator (myself) after a short guidance of about an hour. An experienced operator would definitely get a better contrast.